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(54) MANUFACTURING METHOD OF TRIPOLAR FIELD-EMISSION ELEMENT USING CARBON NANOTUBE

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a manufacturing method of a tripolar field-emission element using carbon nanotubes, superior in electron emission characteristics.

SOLUTION: In this manufacturing method, catalyst layers 9 are formed on a cathode 2, in a state with or without forming a base layer, and carbon nanotubes 10 are grown on the catalyst layers by Spint method. On the catalyst layer 9' outside a micro cavity 6, a nonreactive layer 77 is formed, and only on the catalyst layer 9 inside the micro cavity 6, carbon nanotubes are grown. In this way, even when a separation layer 7

is etched and removed, due to the nonexistence of outside carbon nanotubes, carbon nanotubes will not flow into the micro-cavity 6. Thus, this method has an advantage of increasing production yield and reducing manufacturing cost.

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CLAIMS

[Claim(s)]

[Claim 1] (a) Cathode, an insulating layer, and the gate are formed in order on a tooth-back glass substrate. The phase which opening is formed in said gate and a micro mold cavity is formed in said insulating layer of this opening, and performs inclination vacuum evaporation and forms a detached core on said gate which has such structure, (b) In case a carbon nanotube is grown up on the cathode in said micro mold cavity, while performing inclination vacuum evaporation the phase which forms the catalyst bed which plays the role of a catalyst, and on the (c) aforementioned catalyst bed The phase which forms the non-reacting layer which is the part by which a carbon nanotube is not formed in the catalyst bed of the remaining part which removed the catalyst bed of the

predetermined part in said micro mold cavity, and removed said catalyst bed, (d) The manufacture approach of 3 pole field emission component using the carbon nanotube characterized by including the phase of growing up a carbon nanotube on the catalyst bed which comes to remain after removing the catalyst bed of the predetermined part in said micro mold cavity, and the phase of removing the (e) aforementioned detached core.

[Claim 2] It is the manufacture approach of 3 pole field emission component using the carbon nanotube according to claim 1 characterized by forming said insulating layer in said phase (a) by making the thickness of 5-10 micrometers vapor-deposit SiO_2 or Si_3N_4 , respectively, and forming said opening in the diameter of 5-10 micrometers.

[Claim 3] It is the manufacture approach of 3 pole field emission component using the carbon nanotube according to claim 1 characterized by being formed when said catalyst bed makes nickel or Co vapor-deposit in said phase (b).

[Claim 4] In said phase (c), said non-reacting layer is the manufacture approach of 3 pole field emission component using the carbon nanotube according to claim 1 characterized by the thing as which it was chosen from the groups which consist of Cr, W, aluminum, Mo, and Si, and which is formed by kind at least.

[Claim 5] In said phase (d), said carbon nanotube is the manufacture approach of 3 pole field emission component using the carbon nanotube according to claim 1 characterized by making it grow up and being formed with an arc discharge method or a CVD method.

[Claim 6] (a) Cathode, an insulating layer, and the gate are formed in order on a tooth-back glass substrate. The phase which opening is formed in said gate and a micro mold cavity is formed in said insulating layer of this opening, and performs inclination vacuum evaporation and forms a detached core on said gate which has such structure, (b) The phase which performs inclination vacuum evaporation and forms the base layer of a cone configuration on the cathode in said micro mold cavity, (c) In case a carbon nanotube is grown up on said base, while performing inclination vacuum evaporation the phase which forms the catalyst bed which plays the role of a catalyst, and on the (d) aforementioned catalyst bed The phase which forms the non-reacting layer which is the part by which a carbon nanotube is not formed in the catalyst bed of the remaining part which removed the catalyst bed of the predetermined part in said micro mold cavity, and removed said catalyst bed, (e) The manufacture approach of 3 pole field emission component using the carbon nanotube characterized by including the phase of growing up a carbon

nanotube on the catalyst bed which comes to remain after removing the catalyst bed of the predetermined part in said micro mold cavity, and the phase of removing the (f) aforementioned detached core.

[Claim 7] It is the manufacture approach of 3 pole field emission component using the carbon nanotube according to claim 6 characterized by for said insulating layer making the thickness of 5-10 micrometers vapor-deposit SiO_2 or Si_3N_4 , forming it in said phase (a), and forming said opening in the diameter of 5-10 micrometers.

[Claim 8] In said phase (b), said base layer is the manufacture approach of 3 pole field emission component using the carbon nanotube according to claim 6 characterized by the thing as which it was chosen from the groups which consist of Au, Pt, and Nb, and which is formed by kind at least.

[Claim 9] It is the manufacture approach of 3 pole field emission component using the carbon nanotube according to claim 6 characterized by for said catalyst bed making nickel or Co vapor-deposit in said phase (c) phase, and being formed.

[Claim 10] In said phase (d) phase, said non-reacting layer is the manufacture approach of 3 pole field emission component using the carbon nanotube according to claim 6 characterized by the thing as which it was chosen from the groups which consist of Cr, W, aluminum, Mo, and Si, and which is formed by kind at least.

[Claim 11] In said phase (e), said carbon nanotube is the manufacture approach of 3 pole field emission component using the carbon nanotube according to claim 6 characterized by making it grow up and being formed with an arc discharge method or a CVD method.

[Claim 12] (a) Cathode, an insulating layer, and the gate are formed in order on a tooth-back glass substrate. The phase which opening is formed in said gate and a micro mold cavity is formed in said insulating layer of this opening, and performs inclination vacuum evaporation and forms a detached core on said gate which has such structure, (b) The phase which forms the catalyst bed which plays the role of a catalyst on the cathode in said detached core and said micro mold cavity in case a carbon nanotube is grown up, (c) The manufacture approach of 3 pole field emission component using the carbon nanotube characterized by including the phase of removing the catalyst bed on said detached core while removing said detached core, and the phase of growing up a carbon nanotube on the catalyst bed in a (d) aforementioned micro mold cavity.

[Claim 13] It is the manufacture approach of 3 pole field emission component using the carbon nanotube according to claim 12 with which thickness makes 5-10 micrometers vapor-deposit SiO_2 or Si_3N_4 , said

insulating layer is formed in said phase (a), and said opening is characterized by forming a diameter in 5-10 micrometers.

[Claim 14] It is the manufacture approach of 3 pole field emission component using the carbon nanotube according to claim 12 characterized by for said catalyst bed making nickel or Co vapor-deposit in said phase (b), and being formed.

[Claim 15] It is the manufacture approach of 3 pole field emission component using the carbon nanotube according to claim 12 characterized by growing up said carbon nanotube with an arc discharge method or a CVD method in said phase (d) phase, and being formed.

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the manufacture approach of 3 pole field emission component using the carbon nanotube excellent in the electron emission characteristic.

[0002]

[Description of the Prior Art] An electron is made to emit from a microchip in the conventional field emission display device (field emission display;FED) by using the gate for the microchip arranged at intervals of [fixed] the Spindt (Spind't) mold field emission array (field emitter array;FEA) which mainly consists of semi-conducting material, such as metals, such as Mo, and Si, and applying strong electric field.

[0003] Thus, it is accelerated towards the anode plate which has required hundreds thru/or the electrical potential difference of thousands of volts, and the emitted electron emits light by colliding with the fluorescent substance applied to this anode plate. Gate voltage required since the metal and semi-conducting material which are used for the microchip of the field emission display device of such a conventional method have the large work function, in order to make an electron emit will become quite high.

[0004] Therefore, when the gas ion which was ionized when the particle of the residual gas in a vacuum collided with an electron, and was ionized in this way strikes the front face of a microchip (Sputtering), damage is done to a microchip and the microchip as a source of electron

emission may be destroyed. Moreover, when said gas ion and electron collide, the particle which constitutes said fluorescent substance falls, a microchip is polluted, and the engine performance of said source of electron emission may be lowered.

[0005] Such a series of troubles have a possibility of contracting said engine performance and life of FEA. In order to overcome such a trouble, if a microchip is manufactured using the carbon nanotube which whose electron emission electrical potential difference was low instead of the existing metal or semi-conducting material, and was excellent in chemical safety, the engine performance and life of FEA are extensible.

[0006] As a technique which vapor-deposits a carbon nanotube, the current arc discharge method and the method from laser ** (laser ablation; laser ablation) are used universally. However, by such approach, there is a trouble that it is difficult a problem to be not only to mass-produce a carbon nanotube, but to control and manufacture structure by low cost.

[0007] gaseous-phase vacuum deposition develops as an approach for overcoming such a trouble in recent years -- having -- **** -- as such an approach -- thermochemistry gaseous-phase vacuum deposition (thermal CVD) (67 Appl.Phys.Lett., 2477 (1995)) and MPECVD -- there are law (72 Appl.Phys.Lett., 3437 (1998)), an ion beam radiation method (69 Appl.Phys.Lett., 4174 (1996)), etc.

[0008] To electric field with possible making an electron emit from the diamond thin film which is excellent as an ingredient of the source of electron emission being about 10v/micrometer, with the carbon nanotube, an electron can be made to emit easily also by electric field 1v [/micrometer] or less, and the carbon nanotube which has such a property attracts attention as a next-generation source ingredient of electron emission.

[0009] Drawing 1 is the typical sectional view showing roughly the structure of a field emission display device where the existing carbon nanotube was used. The field emission component using the existing carbon nanotube as shown in drawing 1 has 2 pole structures of providing the fluorescent substance 13 applied on the anode plate 12 respectively formed on the field where the front substrate 11 which countered mutually at fixed spacing and has been arranged and the tooth-back substrates 16, and these two substrates counter, cathode 15, and an anode plate 12, and the carbon nanotube 14 applied on cathode 15.

[0010] In manufacturing the field emission display device using such a carbon nanotube, establishing the manufacture approach of the carbon nanotube moreover vapor-deposited by low cost to a large area using the

approach of controlling the structure of a carbon nanotube poses a problem first. In order to attain such a purpose, it is thought easiest to use gaseous-phase vacuum deposition. It is possible to form a carbon nanotube with this gaseous-phase vacuum deposition as well as the above mentioned arc discharge method and the above mentioned method from laser **, using silicide, such as transition metals, such as nickel and Fe, and CoSi₂, as a catalyst.

[0011] The actual condition is that the carbon nanotube formed with old gaseous-phase vacuum deposition makes a carbon nanotube vapor-deposit, and is formed with not the structure by which patterning was carried out to the predetermined pattern but the 2 above mentioned pole structures, and a similar random gestalt. Since need to have the laminated structure of 3 pole structures like an insulating layer or the gate and it is not necessary to constitute it from such 2 pole structures, even if it uses such gaseous-phase vacuum deposition, it can manufacture easily. However, since it is difficult to control the electron emitted from the source of electron emission by the field emission component of 2 pole structures of having structure simple in this way, it is difficult to demonstrate the function as a display device smoothly.

[0012] The electric-field emitter using the carbon nanotube which has the structure which can control the electron emitted from such a source of electron emission is indicated by the U.S. Pat. No. 5,773,834 number. It is thought that the electric-field emitter proposed by this patent can control the electron made to emit by constituting a gate electrode from 3 pole structures equipped with the reticulated grid to some extent. However, such a carbon nanotube has the problem that it is not the structure which can be easily manufactured with gaseous-phase vacuum deposition.

[0013]

[Problem(s) to be Solved by the Invention] This invention has the purpose in being created in order to improve a trouble which was described above, and offering the manufacture approach of 3 pole electron emission component using the carbon nanotube which can manufacture the source of electron emission for a carbon nanotube with a carbon nanotube using the Spindt (Spind't) process.

[0014]

[Means for Solving the Problem] The manufacture approach of 3 pole electron emission component using the carbon nanotube applied to this invention in order to attain the above purposes (a) Cathode, an insulating layer, and the gate are formed in order on a tooth-back glass substrate. The phase which performs inclination vacuum evaporation and

forms a detached core on said gate of the structure where opening was formed in said gate and the micro mold cavity corresponding to said opening was formed in said insulating layer, (b) The phase which forms the catalyst bed which carries out the role of a catalyst in case a carbon nanotube is grown up on the cathode in said micro mold cavity, (c) Phase which forms the non-reacting layer in which a carbon nanotube is not made to form in the catalyst bed of the remaining part which performed inclination vacuum evaporation on said catalyst bed, and excepted the catalyst bed in said micro mold cavity (in other words) While performing inclination vacuum evaporation on said catalyst bed, the catalyst bed of the predetermined part in said micro mold cavity is removed. The phase which forms the non-reacting layer which is the part by which a carbon nanotube is not formed in the catalyst bed of the remaining part which removed said catalyst bed, (d) Phase of growing up a carbon nanotube on the catalyst bed in said micro mold cavity (in other words) It is characterized by including the phase of growing up a carbon nanotube on the catalyst bed which comes to remain after removing the catalyst bed of the predetermined part in said micro mold cavity, and the phase of removing the (e) aforementioned detached core.

[0015] In this invention, said insulating layer vapor-deposits and forms SiO_2 or Si_3N_4 in the thickness of 5-10 micrometers in the aforementioned (a) phase, respectively, said opening is formed in the diameter of 5-10 micrometers, and it is the aforementioned (b) phase. Said catalyst bed vapor-deposits and forms nickel or Co, and it is the aforementioned (c) phase. Said non-reacting layer is formed at least by a kind of matter chosen from the groups which consist of Cr, W, aluminum, Mo, and Si, it is the aforementioned (d) phase, and, as for said carbon nanotube, it is desirable to make it grow up with an arc discharge method or a CVD method.

[0016] Moreover, the manufacture approach of 3 pole electron emission component using other carbon nanotubes to the pan applied to this invention in order to attain the above purposes (a) Cathode, an insulating layer, and the gate are formed in order on a tooth-back glass substrate. The phase which performs inclination vacuum evaporation and forms a detached core on said gate of the structure where opening was formed in said gate and the micro mold cavity corresponding to said opening was formed in said insulating layer (in other words) Cathode, an insulating layer, and the gate are formed in order on a tooth-back glass substrate, and opening is formed in said gate. The phase which a micro mold cavity is formed in said insulating layer of this opening, and performs inclination vacuum evaporation and forms a detached core on

said gate which has such structure, (b) The phase which performs inclination vacuum evaporation and forms a truncated-cone-like base layer on the cathode in said micro mold cavity, (c) The phase which forms the catalyst bed which carries out the role of the catalyst of carbon nanotube growth on said base, (d) Phase which forms the non-reacting layer in which a carbon nanotube is not made to form in the catalyst bed of the remaining part which performed inclination vacuum evaporation on said catalyst bed, and excepted the catalyst bed in said micro mold cavity (in other words) While performing inclination vacuum evaporation on said catalyst bed, the catalyst bed of the predetermined part in said micro mold cavity is removed. The phase which forms the non-reacting layer which is the part by which a carbon nanotube is not formed in the catalyst bed of the remaining part which removed said catalyst bed, (e) Phase of growing up a carbon nanotube on the catalyst bed in said micro mold cavity (in other words) The phase of growing up a carbon nanotube on the catalyst bed which comes to remain after removing the catalyst bed of the predetermined part in said micro mold cavity, and (f) It is characterized by including the phase of removing said detached core. In this invention, said insulating layer vapor-deposits and forms SiO_2 or Si_3N_4 in the thickness of 5-10 micrometers in the aforementioned (a) phase, said opening is formed in the diameter of 5-10 micrometers, and it is the aforementioned (b) phase. Said base layer is formed at least by a kind of matter chosen from the groups which consist of Au, Pt, and Nb, and is the aforementioned (c) phase. Said catalyst bed vapor-deposits and forms nickel or Co, and it is the aforementioned (d) phase. Said non-reacting layer is formed at least by a kind of matter chosen from the groups which consist of Cr, W, aluminum, Mo, and Si, it is the aforementioned (e) phase, and, as for said carbon nanotube, it is desirable to make it grow up with an arc discharge method or a CVD method.

[0017] Furthermore, the manufacture approach of 3 pole electron emission component using other carbon nanotubes to the pan applied to this invention in order to attain the above purposes (a) Cathode, an insulating layer, and the gate are formed in order on a tooth-back glass substrate. The phase which opening is formed in said gate and a micro mold cavity is formed in said insulating layer of this opening, and performs inclination vacuum evaporation and forms a detached core on said gate which has such structure, (b) The phase which forms the catalyst bed which plays the role of a catalyst on the cathode in said detached core and said micro mold cavity in case a carbon nanotube is grown up, (c) It is characterized by including the phase of removing the

catalyst bed on said detached core while removing said detached core, and the phase of growing up a carbon nanotube on the catalyst bed in a (d) aforementioned micro mold cavity. In this invention, thickness makes 5-10 micrometers vapor-deposit said insulating layer, form SiO₂ or Si₃N₄ in said phase (a), and a diameter forms said opening in 5-10 micrometers, are said phase (b), said catalyst bed makes nickel or Co vapor-deposit, and it forms, and is said phase (d) phase, and, as for said carbon nanotube, it is desirable to make it grow up with an arc discharge method or a CVD method.

[0018]

[Embodiment of the Invention] Hereafter, the manufacture approach of 3 pole electron emission component using the carbon nanotube concerning this invention is explained to a detail, referring to a drawing.

[0019]

[Example] <Example 1> The manufacture approach of the 1st example is explained as follows first, referring to drawing 2 thru/or drawing 8 . As shown in drawing 2 , on the tooth-back glass substrate 1, a transparent electrode metallurgy group etc. is used and cathode 2 is formed. As shown in drawing 3 , the insulating layer 3 for vapor-depositing an insulating material like SiO₂ and Si₃N₄ in thickness of 5-10 micrometers, and insulating the gate 4 and cathode 2 is formed on cathode 2, and the gate 4 is formed on it. As shown in drawing 4 , opening 5 is formed in consideration of the thickness of an insulating layer 3 on the gate 4 at the diameter of about about 5-10 micrometers.

[0020] As shown in drawing 5 , with the application of said gate 4, an insulating layer 3 is etched as a mask, and the micro mold cavity 6 is formed. As shown in drawing 6 , inclination vacuum evaporation is carried out using the vacuum evaporation equipment which has directivity, and a detached core (sacrifice layer) 7 is formed. As shown in drawing 7 , nickel and matter like Co which carry out the role of the catalyst of carbon nanotube growth are vapor-deposited perpendicularly, and a catalyst bed 9 and 9' are formed in the front face of said detached core 7, and the bottom of said micro mold cavity section 6. As shown in drawing 8 , catalyst bed 9' which separated said detached core 7 and was formed on the detached core 7 is removed.

[0021] As shown in drawing 9 , a carbon nanotube 10 is grown up on the catalyst bed 9 currently formed in the bottom of said micro mold cavity section 6. Growth of the partial carbon nanotube 10 to such a catalyst bed 9 is possible without the decision of special process conditions also under a CVD process. Although a carbon nanotube 10 grows only mainly on a catalyst bed 9, it is formed also on the gate 4. By doing in

this way, the carbon nanotube 10 by which self-alignment was carried out is formed in the interior of the micro mold cavity 6, and 3 pole field emission component is obtained. However, on the gate 4, the carbon nanotube which has magnitude or thickness to the extent that it can ignore is formed. The casting plan which prevents growth of the carbon nanotube on such the gate 4 is shown by the example 2 and example 3 which are explained henceforth.

[0022] In the following examples 2 and examples 3, the substrate which passed through the process of the substrate and drawing 2 which passed through the process of drawing 2 explained in said example 1 thru/or drawing 7 thru/or drawing 6 is applied respectively.

After passing through the process of drawing 2 explained in the <example 2> example 1 thru/or drawing 7 , as shown in drawing 10 , the non-reacting layer 77 is formed in catalyst bed 9' of the remaining part which carried out inclination vacuum evaporation using the vacuum evaporation equipment which has directivity, and excepted the catalyst bed 9 in a mold cavity 6 using matter, such as Cr, W, aluminum, Mo, and Si, so that a carbon nanotube may not be formed. As shown in drawing 11 , a carbon nanotube 10 is grown up on said catalyst bed 9 using an arc discharge method, a CVD method, etc. At this time, a carbon nanotube hardly grows on the non-reacting layer 77 for the property of the non-reacting layer 77. As shown in drawing 12 , a detached core 7 is removed and catalyst bed 9' on a detached core 7 and the non-reacting layer 77 are removed. If it does in this way, a carbon nanotube will not exist in the exterior of the micro mold cavity 6. By doing in this way, the carbon nanotube 10 by which self-alignment was carried out is formed in the interior of the micro mold cavity 6, and 3 pole field emission component is obtained.

[0023] After passing through the process of drawing 2 explained in the <example 3> example 1 thru/or drawing 6 , as shown in drawing 13 , conductivity like Au, Pt, and Nb forms the base layer 8 and 8' in the bottom of said detached core 7 and the micro mold cavity section 6 with vacuum deposition using the good matter. The base layer 8 formed in the micro mold cavity section 6 is applied in order to embody the still more detailed self-alignment structure of the carbon nanotube 10 formed in the micro mold cavity section 6, while aiming at more effective electric contact to cathode 2 and the carbon nanotube 10 obtained in the phase which follows.

[0024] matter like [as shown in drawing 14] nickel and Co which carry out the role of the catalyst of carbon nanotube growth -- perpendicular -- vapor-depositing -- the base layer 8 and 8' -- a catalyst bed 9 and

9' are formed upwards. As shown in drawing 15 , the non-reacting layer 77 is formed in catalyst bed 9' of the remaining part which carried out inclination vacuum evaporation using the vacuum evaporation equipment which has directivity, and excepted the catalyst bed 9 in a mold cavity 6 using the matter of Cr, W, aluminum, Mo, and Si so that a carbon nanotube may not be formed. As shown in drawing 16 , a carbon nanotube 10 is grown up using an arc discharge method, a CVD method, etc. If a detached core 7 is removed in this condition, the carbon nanotube 10 by which self-alignment was carried out will be formed in the interior of the micro mold cavity 6 as base layer 8' of the exterior of a slot, catalyst bed 9', and the non-reacting layer 77 removed with a detached core 7 and shown in drawing 17 .

[0025] 3 pole current potential property stabilized when 3 pole field emission component pass such a production process impressed gate voltage V_g and plate voltage V_a , as shown in drawing 18 is acquired. Drawing 19 is a SEM photograph (scanning electron microscope photograph) in which the condition that the catalyst bed was formed in the bottom of the micro mold cavity section in the process mentioned above is shown, and drawing 20 and drawing 21 show the condition that the carbon nanotube grew on said catalyst bed.

[0026] the graph which shows change of the emission current (emission current, μA) which drawing 22 requires for change of gate voltage V with 3 pole field emission component obtained by the approach of above this inventions -- it is -- each anode electrical potential difference (1400V, 1800V, 1900V) -- change of the emission current is shown independently. The component which is in the bottom in a graph by drawing 22 shows the time of bias not starting the gate.

[0027]

[Effect of the Invention] the condition that the manufacture approach of 3 pole field emission component using the carbon nanotube concerning this invention forms a base layer on cathode as explained above, or there is nothing an end again -- a catalyst bed -- forming -- Spindt -- it is the approach of growing up a carbon nanotube on a catalyst bed by law. Therefore, by forming a non-reacting layer on the catalyst bed of the exterior of a micro mold cavity, and growing up a carbon nanotube only on the catalyst bed inside a micro mold cavity, when etching and removing a detached core, and an external carbon nanotube does not exist, a carbon nanotube does not flow in in a micro mold cavity. Therefore, there is the advantage to which a production cost becomes low at the same time production yield increases.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is the rough vertical cross section of the pole field emission component 2 using the existing carbon nanotube.

[Drawing 2] Drawing 2 is process drawing of the 1st example in the manufacture approach of 3 pole field emission component using the carbon nanotube concerning this invention.

[Drawing 3] Drawing 3 is process drawing of the 1st example in the manufacture approach of 3 pole field emission component using the carbon nanotube concerning this invention.

[Drawing 4] Drawing 4 is process drawing of the 1st example in the manufacture approach of 3 pole field emission component using the carbon nanotube concerning this invention.

[Drawing 5] Drawing 5 is process drawing of the 1st example in the manufacture approach of 3 pole field emission component using the carbon nanotube concerning this invention.

[Drawing 6] Drawing 6 is process drawing of the 1st example in the manufacture approach of 3 pole field emission component using the carbon nanotube concerning this invention.

[Drawing 7] Drawing 7 is process drawing of the 1st example in the manufacture approach of 3 pole field emission component using the carbon nanotube concerning this invention.

[Drawing 8] Drawing 8 is process drawing of the 1st example in the manufacture approach of 3 pole field emission component using the carbon nanotube concerning this invention.

[Drawing 9] Drawing 9 is process drawing of the 1st example in the manufacture approach of 3 pole field emission component using the carbon nanotube concerning this invention.

[Drawing 10] Drawing 10 is the sectional view showing the manufacture process of the 2nd example in the manufacture approach of 3 pole field emission component using the carbon nanotube concerning this invention.

[Drawing 11] Drawing 11 is the sectional view showing the manufacture process of the 2nd example in the manufacture approach of 3 pole field emission component using the carbon nanotube concerning this invention.

[Drawing 12] Drawing 12 is the sectional view showing the manufacture process of the 2nd example in the manufacture approach of 3 pole field

emission component using the carbon nanotube concerning this invention.

[Drawing 13] Drawing 13 is the sectional view showing the manufacture process of the 3rd example in the manufacture approach of 3 pole field emission component using the carbon nanotube concerning this invention.

[Drawing 14] Drawing 14 is the sectional view showing the manufacture process of the 3rd example in the manufacture approach of 3 pole field emission component using the carbon nanotube concerning this invention.

[Drawing 15] Drawing 15 is the sectional view showing the manufacture process of the 3rd example in the manufacture approach of 3 pole field emission component using the carbon nanotube concerning this invention.

[Drawing 16] Drawing 16 is the sectional view showing the manufacture process of the 3rd example in the manufacture approach of 3 pole field emission component using the carbon nanotube concerning this invention.

[Drawing 17] Drawing 17 is the sectional view showing the manufacture process of the 3rd example in the manufacture approach of 3 pole field emission component using the carbon nanotube concerning this invention.

[Drawing 18] They are the rough schematics for driving 3 pole carbon nanotube field emission component using the carbon nanotube manufactured by the manufacture process of the 1st example, or the manufacture process of the 2nd example.

[Drawing 19] It is the SEM photograph in which the condition that the catalyst bed was formed in the bottom of the micro mold cavity section by the manufacture approach of 3 pole carbon nanotube field emission component of this invention is shown.

[Drawing 20] The condition that the carbon nanotube grew on the catalyst bed by the manufacture approach of 3 pole carbon nanotube field emission component of this invention is shown.

[Drawing 21] The condition that the carbon nanotube grew on the catalyst bed by the manufacture approach of 3 pole carbon nanotube field emission component of this invention is shown.

[Drawing 22] It is the graph which shows change of the emission current concerning the gate change of potential of 3 pole carbon nanotube field emission component obtained by the manufacture approach of this invention.

[Description of Notations]

- 1 Tooth-Back Glass Substrate
- 2 Cathode
- 3 Insulating Layer
- 4 Gate
- 9 Catalyst Bed
- 10 Carbon Nanotube